ASEC 2024 Conference
The 5th International Electronic Conference on Applied Sciences
04–06 December 2024 | Online
MDPI

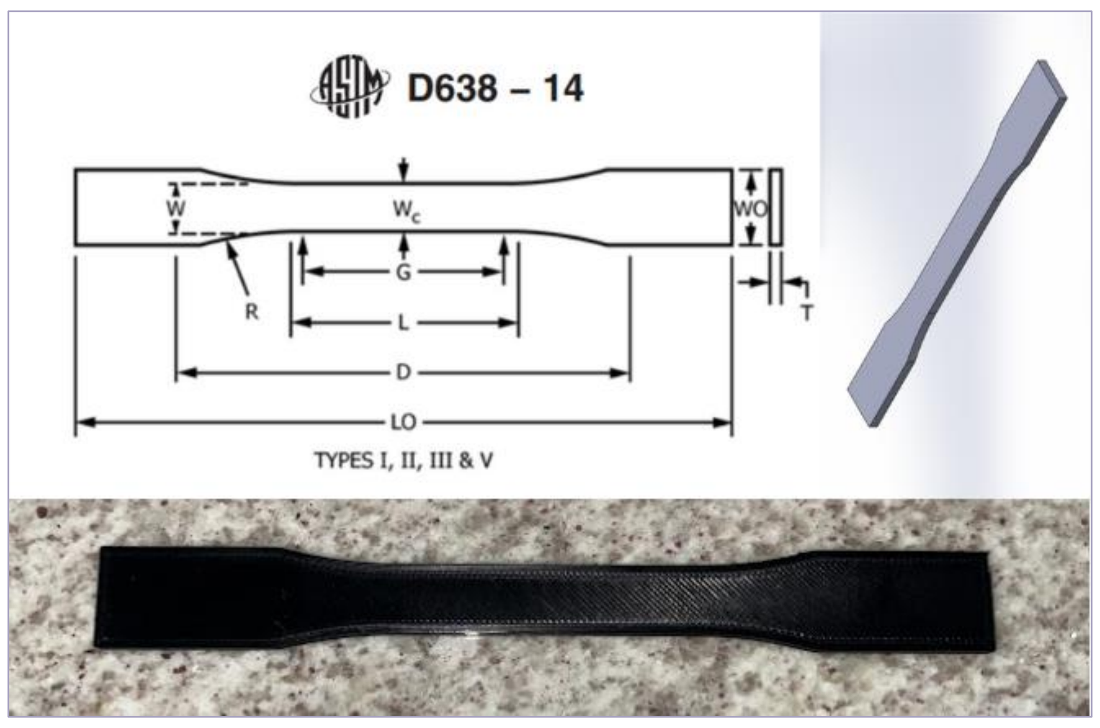
Effects of Infill Density, Geometry, and Thermal Treatment on the Tensile Strength of 3D-Printed ABS Specimens

Carlos José Cortez Loya, José Guadalupe Mercado Rojas, PhD
Tecnológico de Monterrey, Campus Guadalajara

INTRODUCTION & AIM

Polymer 3D printing is a modern manufacturing method that is enabling new research and development of material science and engineering. Contributions to the determination of properties of printed pieces leads to standardization and an increase of usage possibilities. ABS is a suitable option for 3D printing and given its high resistance and good thermal properties it was selected for the printing of probes for tensile tests through the Fused Filament Fabrication (FFF) method.

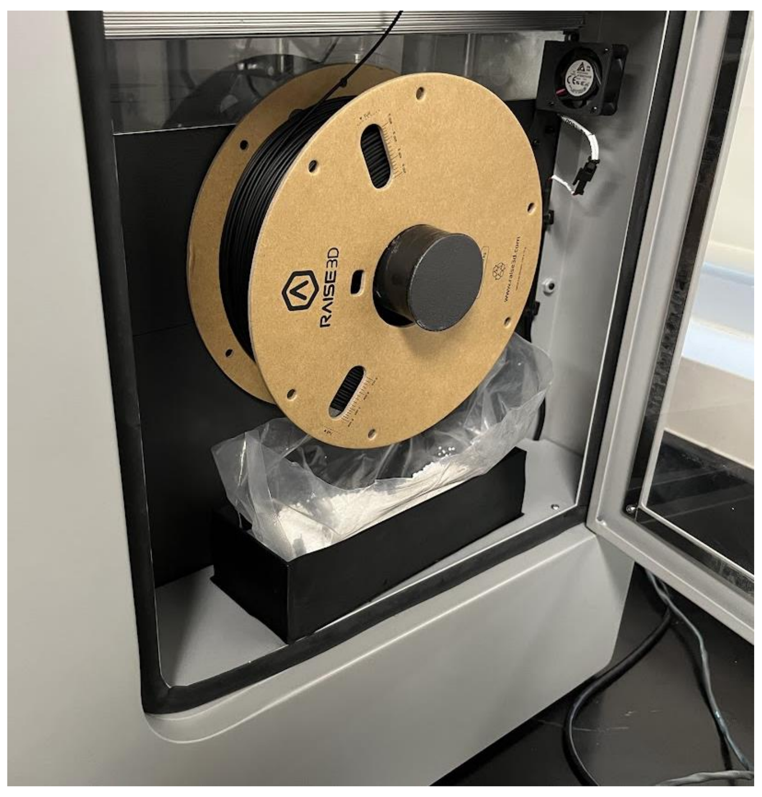
These test specimens were printed with 3 different types of variables. The first was geometric, 3 different thicknesses 3.2, 4.0, and 4.8 mm (area to infill density ratio).The second was the application of an annealing heat treatment, exposition to 100°C in a convection oven for 1 hour and cooldown in room temperature. The last was the percentage of material infill in each of the printed pieces, 20 and 30%. These different variables were combined in the specimens and resulted in 12 groups of 5 repetitions of each variable group.



METHOD

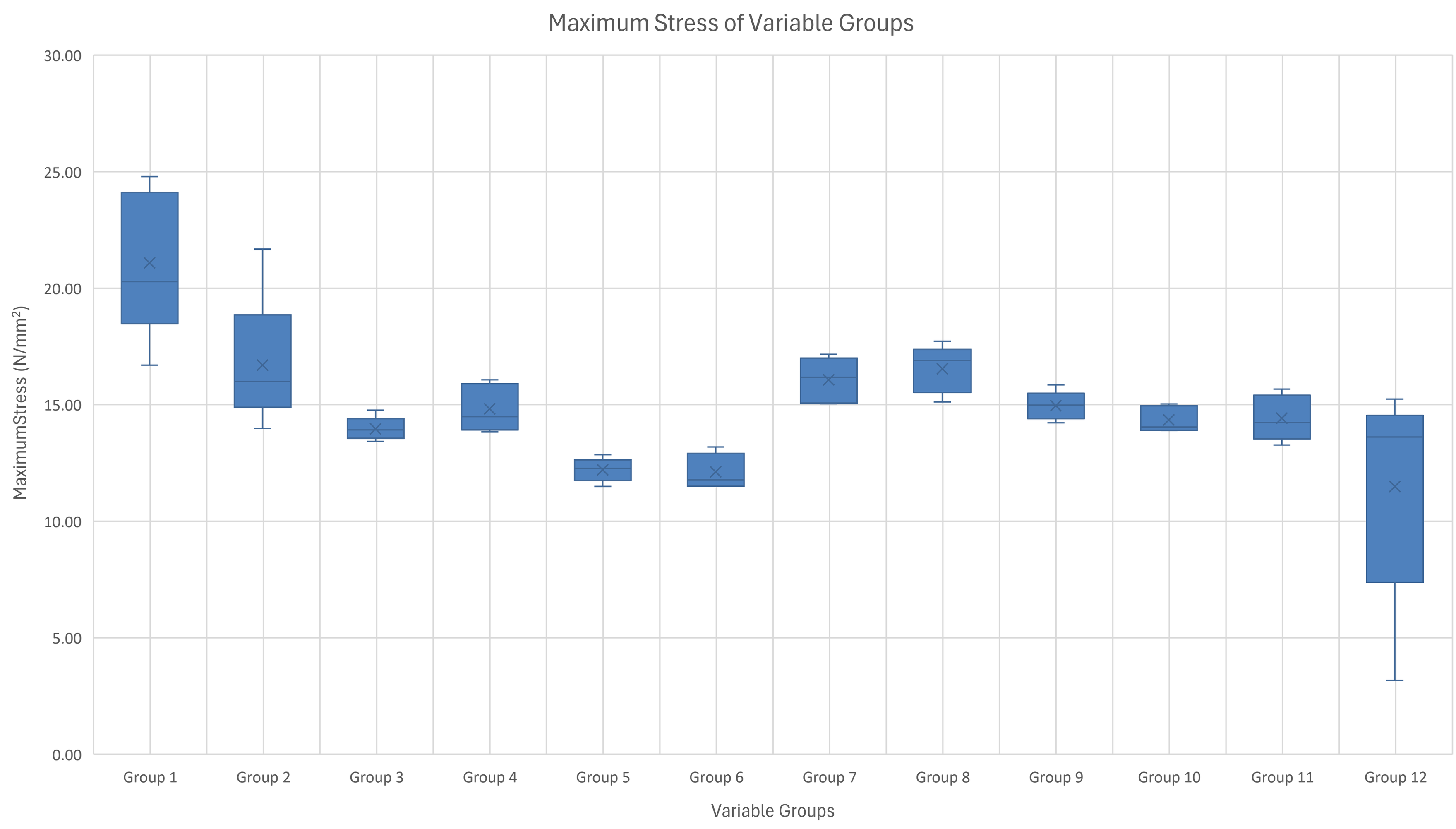
The totality of the pieces were printed with a commercial printer, the INTAMSYS FUNMAT HT with a 0.4 mm diameter nozzle. The printing and subsequential testing were done according to the ASTM D638 norm. The printing settings were the following:

- Nozzle Temperature: 260°C
- Print-bed Temperature: 100°C
- Printing Chamber Temperature: 40-45°C
- Printing Speed: 60 mm/s
- 2.4 mm Thick Raft - Thermal Insulation
- Wall Thickness: 1.2 mm



This was coupled with the use of calcium chloride balls that absorbed humidity that disturbed the printing of the pieces. Afterwards the printed specimens were classified and validated (measured) before being fixed and tested in the universal testing machine. Additionally, they were spray painted at the gauge for further photographic deformation analysis through Digital Image Correlation (DIC).

RESULTS & DISCUSSION

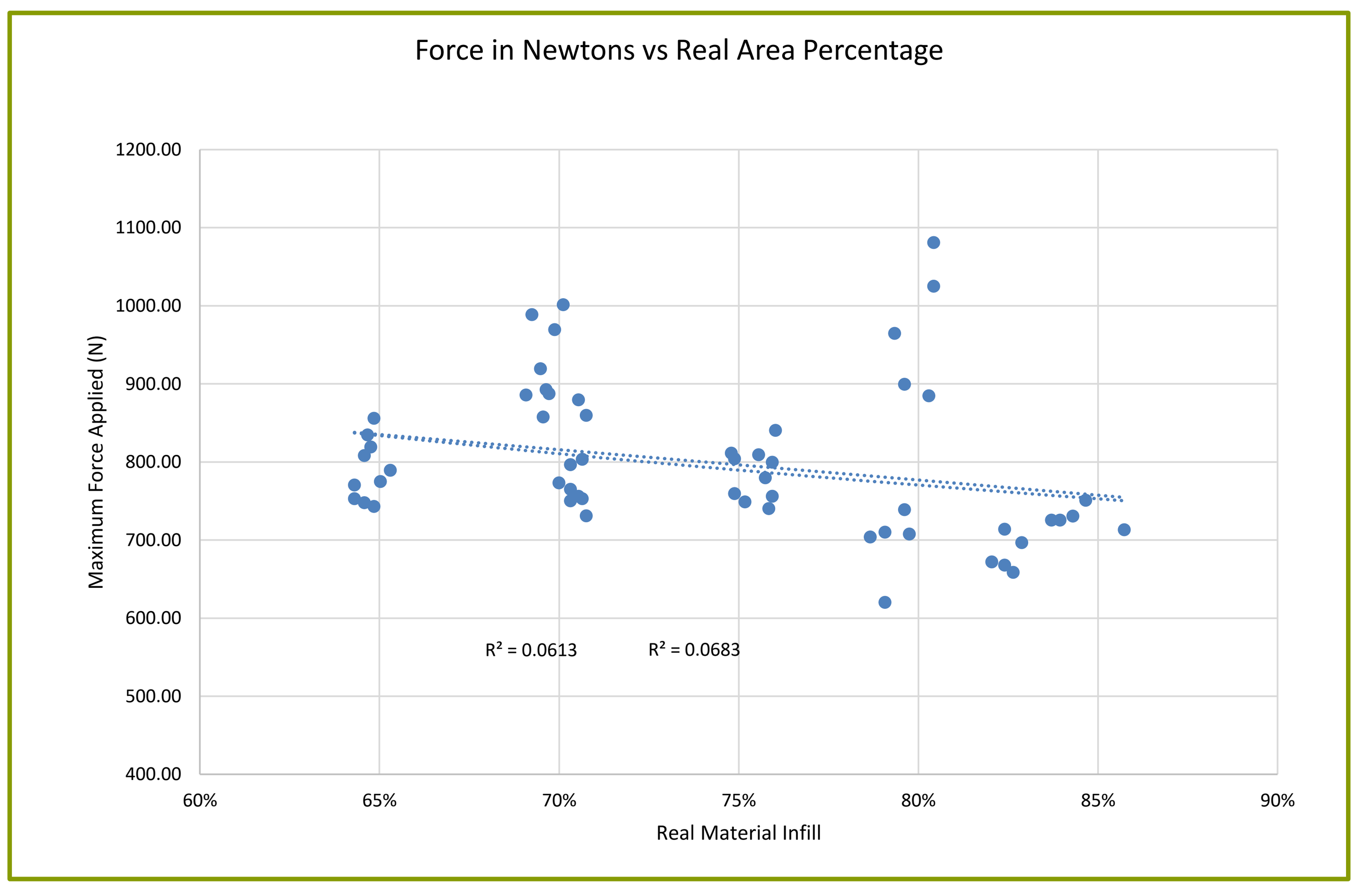


The main results gathered from the universal tester machine came in form of the force applied and its corresponding deformation in any given moment while the upper gripper is moving upwards at a speed of 5 mm/min.

The main analysis relates stress with the different variables to determine if the tensile properties of the ABS probes have been changed or even improved.

First, an analysis of variance (ANOVA) was conducted to determine if the thermal treatment had any effect on the printed specimens. No statistical differentiation was made between the groups with no thermal treatment (1-30) and the ones where the annealing was made (31-60).

The real material infill percentage could be calculated with the data and measurements; thus, it was possible to graph the maximum force applied vs the real material infill percentage. This resulted in regression models of different forms that explained less than 10 % of the variance in the dependent variable.



CONCLUSION

The hypothesis of a positive effect of an annealing thermal treatment on 3D-printed ABS specimens is discarded. Meanwhile, for the variables of thickness and infill percentage, a relationship between the real infill percentage and the amount of force it would be able to withstand could not be established.

FUTURE WORK / REFERENCES

Further analysis through DIC software will be made to gather more and more reliable deformation data. This could lead to predicting the rupture.

- [1] Alagheband, M., Zhang, Q., & Jung, S. (2024). Investigating the influence of infill patterns and mesh modifiers on fatigue properties of 3D printed polymers. International Journal of Fatigue, 187. https://doi.org/10.1016/j.ijfatigue.2024.108463
- [2] Cuan-Urquizo, E., Barocio, E., Tejada-Ortigoza, V., Pipes, R. B., Rodriguez, C. A., & Roman-Flores, A. (2019). Characterization of the mechanical properties of FFF structures and materials: A review on the experimental, computational and theoretical approaches. Materials, 12(6). https://doi.org/10.3390/ma12060895